(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 0 759 645 A2

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
26.02.1997 Bulletin 1997/09

(51) Int. Cl.[6]: **H01P 1/208**

(21) Application number: **96113416.0**

(22) Date of filing: **21.08.1996**

(84) Designated Contracting States:
DE FI FR GB IT SE

(30) Priority: **21.08.1995 JP 211854/95**

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(54) Dielectric resonator apparatus

(57) A dielectric resonator apparatus includes a plurality of TM double-mode dielectric resonators (1a, 1b). Each dielectric resonator (1a, 1b) has a dielectric rod-complex (10a, 10b), a casing (15a, 15b) provided with electrically conductive film (2a, 2e) at the outside surfaces, and metal panels covering the upper and lower openings of the casing. In adjacent TM double-mode dielectric resonators (11a, 11b), at portions of the planes of the two casings (15a, 15b) opposing each other, apertures (29a, 29b) are provided in the direction of the magnetic field generated by two dielectric rods which have the same axial direction. A coupling member (3) is also provided so as to form an electrically conductive loop which goes across the magnetic field.

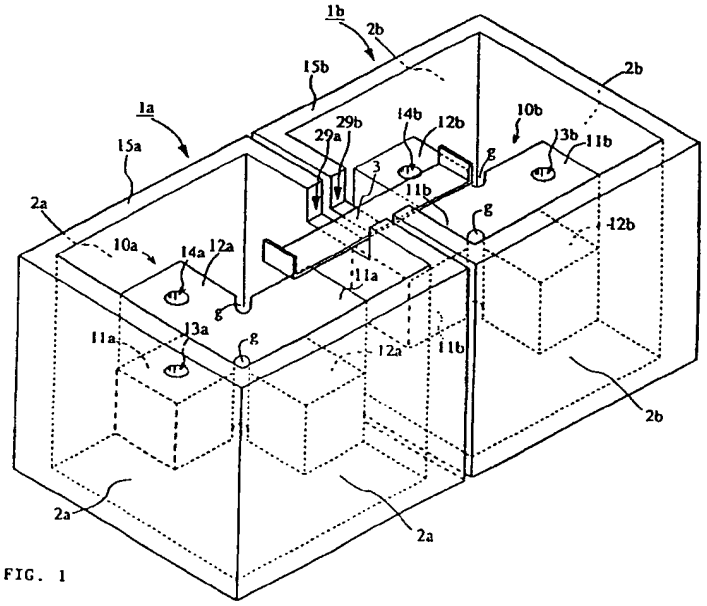

FIG. 1

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tures pass through and cross a magnetic field generated along the respective dielectric rods, whose axes are substantially perpendicular to said apertures; and a conductive loop transverse to said apertures which causes a magnetic coupling between the dielectric rods.

According to another aspect of the present invention, a dielectric resonator apparatus may include a conductive metal rod which is movable near the conductive loop to adjust an amount of said magnetic coupling. The dielectric resonator apparatus may also have a support portion for supporting the metal rod, provided in a wall of the casing near the conductive loop. The conductive metal rod may be a screw member, and the support portion may have screw threads so that the amount of the magnetic coupling can be adjusted by turning the screw member to control a distance between the conductive loop and the conductive metal rod.

According to a further aspect of the present invention, a dielectric resonator apparatus may have a second, flexible metal plate provided near the above-mentioned conductive metal plate; and a member for pressing the second metal plate toward the conductive metal plate to adjust the amount of magnetic coupling.

In accordance with embodiments of the present invention, dielectric rods which are arranged in the same axial direction are selectively coupled with each other through the conductive loop. Thus, it is possible to change the coupling coefficient k by altering the loop area. In such a system, the center of a coupling frequency f_c is kept more constant, as described later, in comparison with the conventional system, even if the coupling coefficient k is changed.

In other words, changes in the resonant frequency of the individual dielectric rods are avoided when the coupling coefficient k is changed. This enables the resonator apparatus to be provided with various characteristics without changing its dielectric parts.

In accordance with another aspect of the present invention, an apparatus composed of multiple resonators is provided, the apparatus including: a plurality of dielectric resonators, the resonators being aligned in series, each of the resonators having: a casing which has electrical conductivity, a dielectric rod-complex provided in the casing, the rod-complex having dielectric rods intersecting with each other; apertures provided in opposed walls of the casings of the dielectric resonators so that the apertures pass through; a first conductive loop provided in at least one of the apertures, the first conductive loop crossing a magnetic field generated by dielectric rods substantially perpendicular to the apertures; a second conductive loop provided in at least another one of the apertures, the second conductive loop crossing a magnetic field generated by dielectric rods substantially parallel to the apertures.

Other aspects and advantages of the invention will be seen in the following detailed description of several embodiments thereof.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1	shows a configuration of two dielectric resonators used in a dielectric resonator apparatus according to a first embodiment of the present invention.
Figs. 2(A) and 2(B)	are partial cross- sections showing examples of coupling members.
Fig. 3	illustrates a way of coupling between resonators through a coupling member.
Fig. 4	shows dimensions of a casing and an aperture.
Fig. 5	shows a relationship between the coupling coefficient k and the coupling frequency f_c in the dielectric resonator apparatus according to the first embodiment.
Figs. 6(A), 6(B) and 6(C)	show a configuration of a coupling member used in a dielectric resonator apparatus according to a second embodiment.
Figs. 7(A) and 7(B)	illustrate a configuration of a dielectric resonator apparatus according to a third embodiment of the invention.
Fig. 8	illustrates a configuration of a dielectric resonator apparatus according to a fourth embodiment.
Fig. 9	is a perspective view showing a configuration of a conventional dielectric resonator apparatus.
Fig. 10	shows a relationship between the coupling coefficient k and the coupling frequency f_c, and f_{even}, f_{odd} in the conventional dielectric resonator apparatus.

sions of the window, and other factors appropriately.

Fig. 6(A) is a plan view of a coupling member 3 (before being mounted to a metal panel) according to a second embodiment of the invention. The coupling member 3 includes a main conductive plate 30 and an adjusting conductive plate 31. Figs. 6(B) and 6(C) are cross-sections showing the coupling member 3 mounted to the metal panel 16. As shown in Fig. 6(B), the adjusting conductive plate 31 is disposed at the inside of the metal panel 16 and the main conductive plate 30. A screw 21 is driven into the metal panel 16 through a screw hole 19. As shown in Fig. 6(C), by turning the screw 21, the adjusting conductive plate 31 is deformed to change the loop area of the conductive loop formed by the main conductive plate 30, the adjusting conductive plate 31, and the metal panel 16. In other words, when the screw 21 is driven toward the inside of the casing, the loop area increases and the coupling coefficient also increases. In this case, since the main conductive plate 30 is not deformed, the distance between the main conductive plate and the dielectric rods in the casings does not change and the resonant frequency of a resonator is not affected. This means that coupling adjustment can be performed independently of the resonant frequency.

Fig. 7(A) is a top view of a dielectric resonator apparatus according to a third embodiment of the invention, before a top metal panel is mounted. Fig. 7(B) is a cross-section along the line X-X in Fig. 7(A) of the apparatus obtained after the metal panel 16 is mounted. The apparatus has TM double-mode dielectric resonators 1a, 1b, and 1c. Between the resonators 1b and 1c, there is provided the same coupling member 3 as that shown in Fig. 1. With this coupling member 3, two dielectric rods 11b and 11c having the same axial direction which are included in dielectric rod-complexes 10b and 10c are magnetically coupled.

There is also provided a coupling loop 42 between dielectric resonators 1a and 1b. This coupling loop 42 is mounted in loop holding sections 41 which isolate and hold the coupling loop at opposing positions in the dielectric resonators 1a and 1b. The coupling loop 42 goes across the magnetic field generated by two dielectric rods 12a and 12b which are arranged in parallel axial directions in dielectric rod-complexes 10a and 10b. Therefore, the dielectric rods 12a and 12b are magnetically coupled through the coupling loop 42.

A metal panel 17 is provided with input and output connectors 26a and 26c. Between the central conductors of the input and output connectors 26a and 26c and the metal plate 17, coupling loops 27a and 27c are mounted. As shown in the figure, the loop plane of the coupling loop 27c is disposed in the direction perpendicular to the plane of the figure, and that of the coupling loop 27a is parallel to the plane of the figure. Therefore, the coupling loop 27a magnetically couples with the dielectric rod 11a, and the coupling loop 27c magnetically couples with the dielectric rod 12c. Since the two resonators formed by the two dielectric rods which form each of dielectric rod-complexes 10a, 10b, and 10c are coupled through the grooves "g" provided at their intersection, the apparatus shown in Figs. 7(A) and 7(B) serves as a six-resonator bandpass filter.

In each complex dielectric rod, frequency adjustment holes are provided in the direction perpendicular to the plane formed by the dielectric rod-complex. When an adjusting member holding section is mounted in each casing, which holds frequency adjustment members for being inserted an adjustable distance into the frequency adjustment holes, and which holds coupling adjustment members for being inserted an adjustable distance into the grooves "g", frequency adjustment and coupling adjustment can be performed at the metal panel 16 or 17.

Fig. 8 shows a configuration of a dielectric resonator apparatus according to a fourth embodiment of the present invention. Fig. 8 is a top view of the apparatus obtained before an upper metal panel is mounted. In the figure, there are shown TM double-mode dielectric resonators 1a, 1b, 1c, 1d, and 1e. A coupling loop 42ab is disposed between resonators 1a and 1b, a coupling member 3bc is disposed between resonators 1b and 1c, a coupling loop 42cd is disposed between resonators 1c and 1d, and a coupling member 3de is disposed between resonators 1d and 1e. Thus a ten-resonator bandpass filter is obtained.

As described above, by disposing a plurality of TM double-mode dielectric resonators and disposing a first coupling device and a second coupling device alternately between them, and by using TM double-mode dielectric resonators in which two resonators in each complex dielectric rod are coupled, two dielectric resonators in each complex dielectric rod are coupled and two adjacent resonators are also coupled. Thus, a dielectric resonator apparatus made up of six, ten or another number of stages of resonators, which serves as a bandpass filter, for example, is obtained.

Claims

1. A dielectric resonator apparatus comprising:

   first and second TM multiple mode dielectric resonators (1a, 1b), said resonators being adjacent to each other, each resonator having:

   a casing (15a, 15b) which has electrical conductivity; and

   a dielectric rod-complex (10a, 10b) disposed in said casing, said rod-complex having at least a pair of dielectric rods (11a, 11b, 12a, 12b) intersecting each other;

   said casings (15a, 15b) of said first and second resonators (1a, 1b) having respective walls opposing each other, a first dielectric rod (11a, 11b) in each said casing (15a, 15b) having an

sponding opposing walls of said casings of each adjacent pair of said dielectric resonators with each said pair of apertures being substantially aligned with each other;

a first type (3bc, 3de) of conductive loop provided in at least one of said pairs of apertures, said first type of conductive loop (3) crossing a magnetic field generated by dielectric rods substantially perpendicular to said apertures; and

a second type (42ab, 42cd) of conductive loop provided in at least another one of said pairs of apertures, said second type of conductive loop crosses a magnetic field generated by dielectric rods substantially parallel to said apertures.

14. A dielectric resonator apparatus of Claim 13, wherein said first and second types of conductive loop (3bc, 3de, 42ab, 42cd) are provided in respective said apertures between alternate adjacent pairs of resonators, so that a dielectric rod-complex at one end of said resonator series is coupled with a dielectric rod-complex at an opposite end of said resonator series.

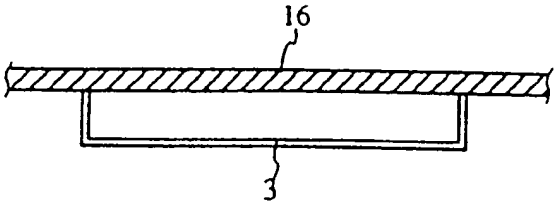

FIG. 2A

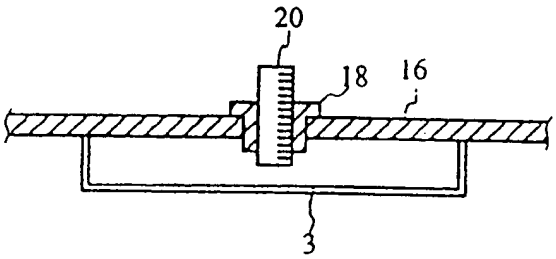

FIG. 2B

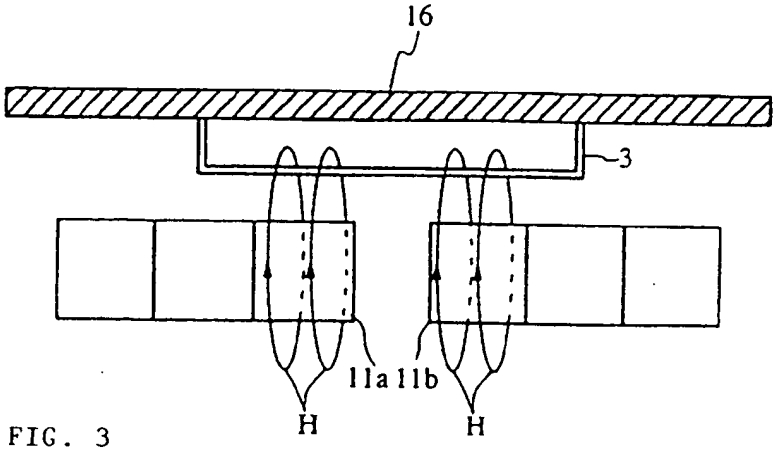

FIG. 3

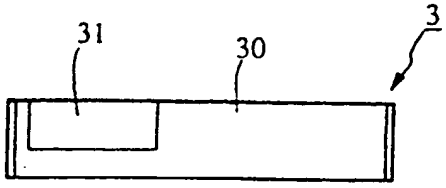

FIG. 6A

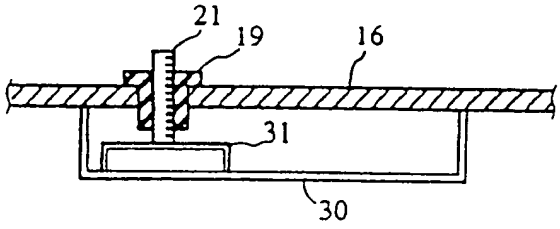

FIG. 6B

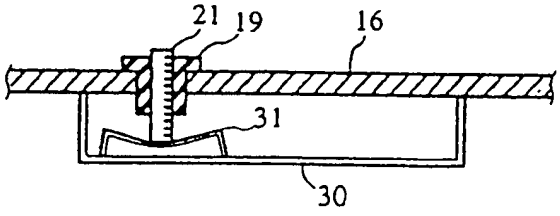

FIG. 6C

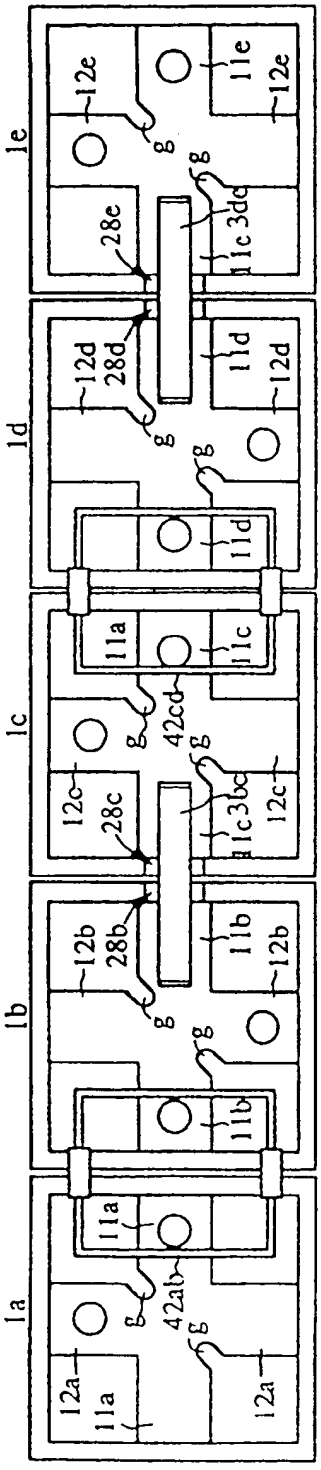

FIG. 8

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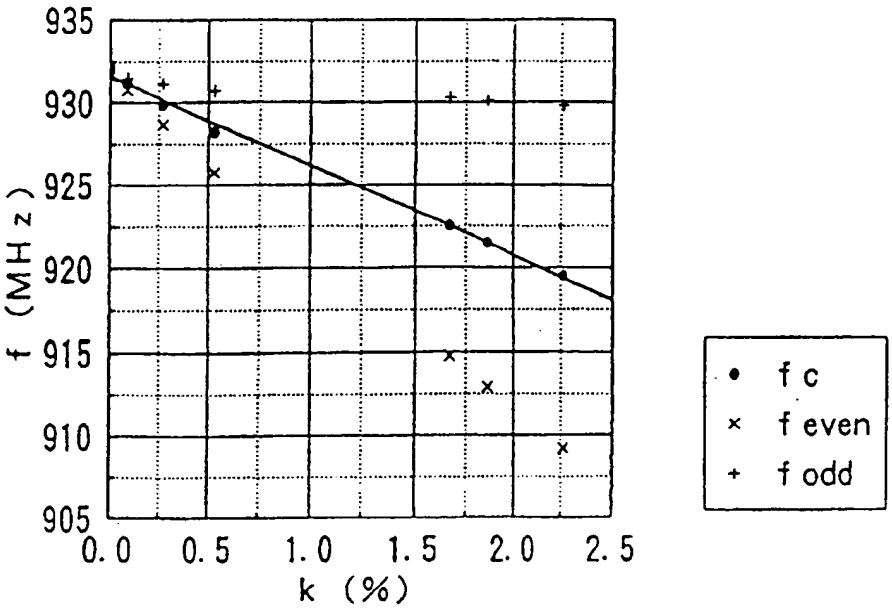

FIG. 10
PRIOR ART

(19) Europäisches Patentamt
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(11) EP 0 759 645 A3

(12) EUROPEAN PATENT APPLICATION

(88) Date of publication A3:
11.03.1998 Bulletin 1998/11

(43) Date of publication A2:
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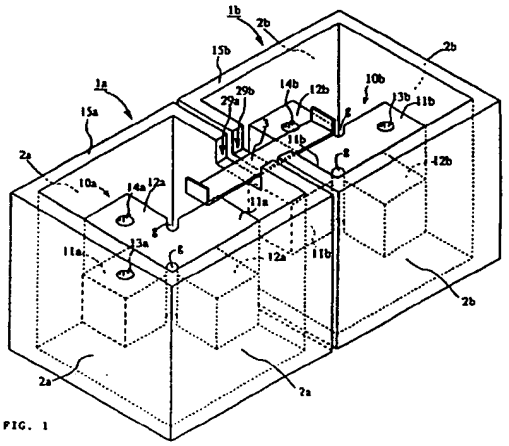

FIG. 1

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